OPTIMIZING BUILDING PLAN FOR A (9m X 12m) HOUSE USING LEARNING SYSTEMS

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***Abstract*- Computer aided design (CAD) has increased by orders of magnitude the power of design tools available to the engineer. Advantages of CAD include the reduction of computation time and therefore its cost, the elimination of the amount of tedious and error-prone detailed calculations done by the engineer, and the ability to develop and analyze much more complete models of structures. All present applications of the computer to structural design deal with later stages of the design process, namely, analysis, proportioning and drafting. In Architecture more prominence is given to outlook and not aesthetics and we as engineers should consider this as a problem and give a solution in the form of optimization. With the advancements of a section of computer science called artificial intelligence, it is now conceivable to create a knowledge-based system to automate or assist in the early, preliminary stages of the civil engineering design process. The purpose of this work is to try and design a set of algorithms to solve the building design problem as an optimization issue.**

Keywords: Artificial intelligence, Design process, Knowledge based system, Optimization, Site Management & Buildings department(SMB).

A. Introduction

"Artificial intelligence is the study of ideas which enable computers to do the things that make people seem intelligent"[2]. Ideas are being developed to facilitate the creation of knowledge-based systems using the experience and knowledge of experts. The civil engineering problems are not repetitive, as the problem definition is always influenced by several factors like financial modes, importance of structure and site conditions and so on. Therefore, although the use of computers in structural analysis started almost four decades ago, the profession has not been able to make use of computers fully, especially, for structural design and planning. This is mainly because of problem specific nature, need for logical reasoning, feasibility constraints and use of experience required in actual design process and planning. Expert systems have capabilities to incorporate some of these requirements for programming a machine for solving a design problem and algorithms are usually constructed with the natural counterpart in mind. Algorithms are intended to solve problems with extreme objectivity. Each algorithm is designed to solve a specific problem with a crisp set of variables. Genetic algorithms on the other hand deal with fuzzy sets where a range of variable values are existing.

B. LITERATURE REVIEW

According to http://repository.cmu.edu/cgi/viewcontent.cgi?article=1019&context=cee, they quote

"In the present practice of preliminary design very little optimization is done and selection is based on rough calculations. Computer assisted preliminary design would provide opportunity for optimization by consideration of a much larger range of alternatives"

C. DESIGN PROCESS

Design can be viewed as the general process in which an idea is developed into detailed instructions for manufacturing a physical product. The design process starts with a definition of a need. The activities that follow can be grouped into four phases [2]:

1. Synthesis: The clarification of the input parameters and their interaction to create a structure that will meet design requirements.

2. Analysis: The modelling and solving of equations to predict the response of a selected structure.

3. Evaluation: The activity of placing a worth on the structure where worth may be cost, safety, or energy consumption.

4. Optimization: the search over the range of possibilities to improve the design as much as possible.

Preliminary design is part of the synthesis phase. In preliminary design alternative structures are developed, a structural configuration is selected, and the preliminary parameters of components are determined.

In the present practice of preliminary design very little optimization is done and selection is based on rough calculations. Computer assisted preliminary design would provide opportunity for optimization by consideration of a much larger range of alternatives. It is possible that computer assisted preliminary design could free the engineer from the implementation of existing structural schemes and allows him to pursue new schemes.

To begin a discussion of CAD, a distinction will be made between computer aided design and design automation [3]. In computer aided design man and machine work together on a problem using the best characteristics of each. In design automation the computer deals with all the demands and constraints without recourse to the designer. The latter may be suitable for design of components, but the method is inherently inflexible, and the exclusion of the designer often leads to dissatisfaction. There are two schools of thought regarding the consequences of CAD. For one, computers remove the repetitive tasks and make room for creativity. The opposing view is that computers stifle creativity by distancing the designer from design. An optimum CAD strategy would be to remove the repetitive tasks without creating a large gap between the designer and the design process.

Today, CAD in structural engineering involves almost exclusively analysis, proportioning of structural components, and production of drawings and schedules. There are very few applications to conceptual and preliminary design. Conceptual and preliminary design are considered the creative aspects of design. Yet, generally the preliminary design process is not new design but redesign, where redesign involves the application of existing structural ideas to a design. New design implies the development of a new structural configuration. Redesign is the application of a set of rules to assign values to predefined variables. Thus, it appears that preliminary structural design process may be placed in a knowledge-based system, where IF THEN rules are used to instantiate values in a data structure [4].

A knowledge-based program is developed using the knowledge of experts. Once the program is developed there should be close interaction between the designer and the computer [5]. The computer should be able to respond to queries on the design process as well as accept additional information. Since a design prepared by the computer follows a limited number of rules, close supervision by the designer is necessary. In this way the designer will realize inadequacies in the existing set of rules and make revisions or additions to the rules when necessary.

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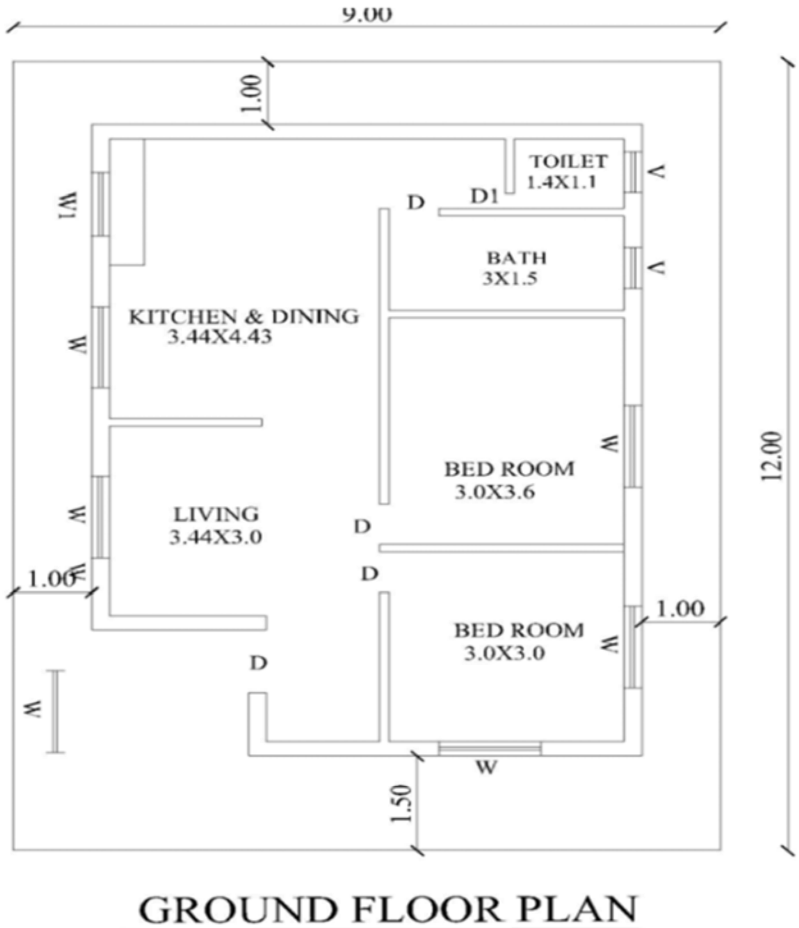
D. METHODOLOGY



SCHEDULE OF OPENINGS:

DOORS		
	D	0.90X2.10
	D1	0.75X2.10
WINDOWS		
	W	1.20X1.37
	W1	1.00X1.37
VENTILATOR		
	V	0.60X0.60

Fig. 1. The schedule of openings for the ground floor plan

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E. PSEUDO CODES

SPACE UTILIZATION

If the building is enclosed only with outer walls
Then space utilization = 100
Else If its provided with interior partition walls which does not lead to passages
Then space utilization = 75%
Else if its provided with interior partition walls which lead to passages
Then space utilization = 50%
Else If the building takes the shape of a maze
Then space utilization = 0

UTILIZATION OF DAYLIGHT

If the window type is fixed with glass panes and completely closed
Then intensity =70%
If the window type is fixed with glass panes completely closed with opaque curtains
Then intensity = 0
If the window type is fixed with glass panes having translucent type of curtains
Then intensity = 60%
If the window type is fixed with glass panes having transparent type of curtains
Then intensity = 70%
If the window type is fixed with tinted glass
Then intensity = 50%
If all the above conditions are provided with mesh
Then intensity is reduced by 20%
If the doors provided in the periphery of the building are completely open
Then intensity = 80%
If the doors provided inside the building
Then intensity = 60%
If the doors are partially open
Then intensity = 40%
End if

ENERGY

l_1=9.68, b_1=7.13
For (l=1; l<=l_1; l++)
For (b=1; b<=b_1; b++)
Solar Intensity=125
Energy=l*b*Solar Intensity
If (energy >= 5400) then
output (l*b)
Exit for

WATER CONSUMPTION

Annual water requirement for 5 people = 547500 lt
If maximum catchment area of 111 m^2 is utilized
Then annual water harvesting potential = 64,646.4 lt
If average catchment area of 55 m^2 is utilized
Then annual water harvesting potential = 32,323.2 lt
Else optimum water harvesting cannot be achieved
End if

MATERIALS

‘M’ main walls and ‘N’ partition walls

If (M=12 & P=8)
Then quantity of earth work excavated = 22.85 m^3
If the SMB is (0.24*0.11*0.07) m^3
Then number of SMB = 12955
End if

F. ANALYSIS

Optimization is achieved using the algorithms mentioned with feedback from user as well. Once the design is complete we compare the design with conventional designs for the utility parameters. This section discusses the results and analysis of the comparison.

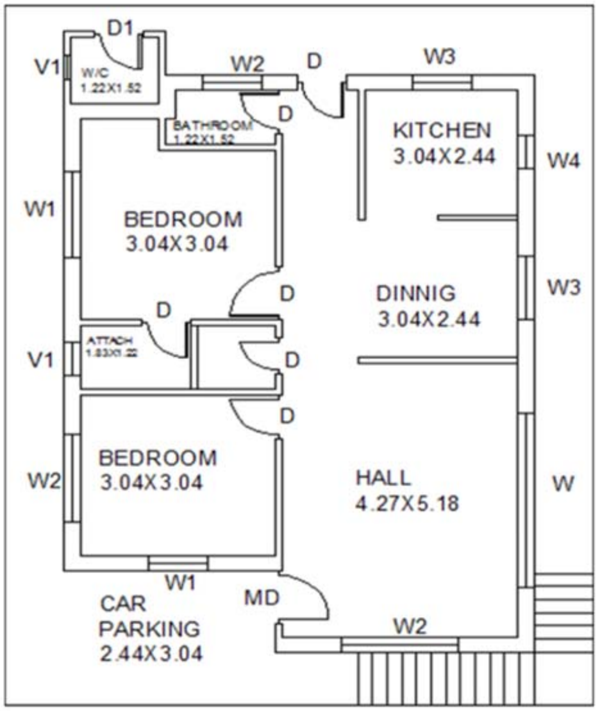
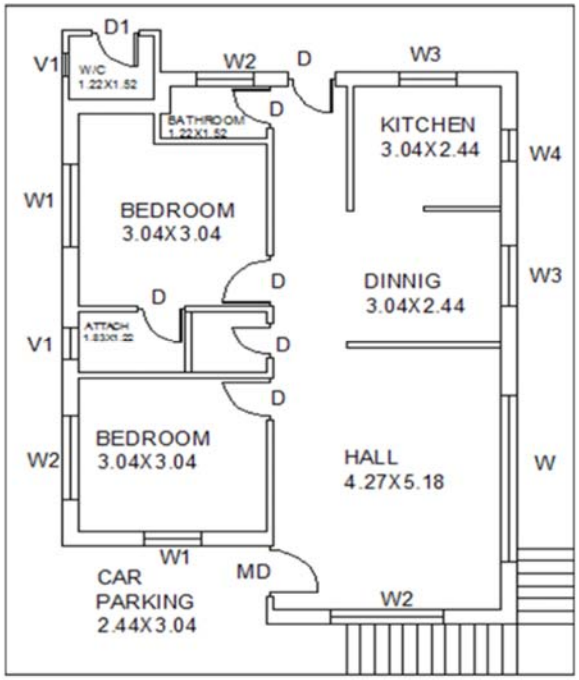


Fig. 2. The design showing the conventional values

TABLE I. Depiction of dimensions of the house plan optimized

NOTES	
MD 1.22 X 2.13	W 1.83 X 1.83
D 0.91 X 2.13	W 1 0.91 X 1.83
D1 0.91 X 2.13	W2 1.52 X 1.25
V 0.91 X 0.61	W3 0.94 X 1.2
V1 0.35 X 0.61	W4 0.35 X 0.61

G. OPTIMIZED PLAN



SCHEDULE OF OPENINGS:

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D	0.90X2.10
D1	0.75X2.10

WINDOWS

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W1	1.00X1.37

VENTILATOR

V	0.60X0.60

Fig. 3. The plan showing the optimized values

TABLE II. Comparison of conventional and optimized parameters

PARAMETER	CONVENTIONAL (%)	OPTIMIZED (%)
1.Space Utilization	40-55	60-65
2.Utilization of daylight	variable	70
3.Energy	variable	100
4.Rain water harvesting potential	Not considered	60
5.Materials(SMB)	Not considered	100

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H. CONCLUSIONS

Optimization for civil engineering plans in architecture is a relatively a new area that requires a lot of work. In this paper, we have attempted to combine fuzzy logic [6] with algorithm and the results are promising. Optimized designs will not only increase the effectiveness of construction but also improve living conditions for people. Such designs will very soon become necessary in this ever-changing economy, increasing impact of population growth on environment, for effective utilization of available resources and preservation of nature.

Using these algorithms and different AI languages an expert system can be developed for the domain to solve several civil engineering problems such as for analysis-design, concrete technology [7], design of R.C.C. and structural steel components behavior modeling of fiber reinforced concrete beams and predicting large deflection response of rectangular plates [8] which can be taken as the further scope of study. Also, these algorithms are preliminary steps which need further refinement to build a toolkit that can efficiently design a house of any dimension and any number of floors. Nevertheless, the platform is still in its infancy and continued growth and development in the field is certainly evident from the recent trends.

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